+10V Precision Voltage Reference

REF-01

FEATURES

- **10 Volt Output** ..... **±0.3% Max**
- **Adjustment Range** ..... **±3% Min**
- **Excellent Temperature Stability** ..... **8.5ppm/°C Max**
- **Low Noise** ..... **30μV_{p-p} Max**
- **Low Supply Current** ..... **1.4mA Max**
- **Wide Input Voltage Range** ..... **12V to 40V**
- **High Load-Driving Capability** **20mA**
- **No External Components**
- **Short-Circuit Proof**
- **MIL-STD-883 Screening Available**
- **Available in Die Form**

ORDERING INFORMATION †

T_A = 25°C ΔV_{OS} MAX (mV)	PACKAGE TO-99	CERDIP 8-PIN	PLASTIC 8-PIN	LCC 20-CONTACT	OPERATING TEMPERATURE RANGE
±30	REF01AJ*	REF01AZ*	—	—	MIL
±30	REF01EJ	REF01EZ	—	—	COM
±50	REF01J*	REF01Z*	—	REF01RC/883	MIL
±50	REF01HJ	REF01HZ	REF01HP	—	COM
±100	REF01CJ	REF01CZ	—	—	COM
±100	—	—	REF01CP	—	XIND
±100	—	—	REF01CS††	—	XIND

* For devices processed in total compliance to MIL-STD-883, add /883 after part number. Consult factory for 883 data sheet.

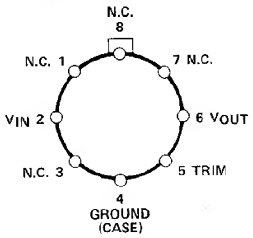
† Burn-in is available on commercial and industrial temperature range parts in CerDIP, plastic DIP, and TO-can packages.

†† For availability and burn-in information on SO and PLCC packages, contact your local sales office.

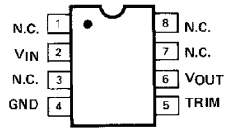
GENERAL DESCRIPTION

The REF-01 precision voltage reference provides a stable +10V output which can be adjusted over a ±3% range with minimal effect on temperature stability. Single-supply operation over an input voltage range of 12V to 40V, low current drain of 1mA, and excellent temperature stability are achieved with an improved bandgap design. Low cost, low noise, and low power make the REF-01 an excellent choice whenever a stable voltage reference is required. Applications include D/A and A/D converters, portable instrumentation, and digital voltmeters. Full military temperature range devices with screening to MIL-STD-883 are available. For guaranteed long-term drift see the REF-10 data sheet.

PIN CONNECTIONS



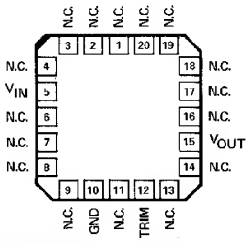
TO-99
(J-Suffix)



EPOXY MINI-DIP
(P-Suffix)

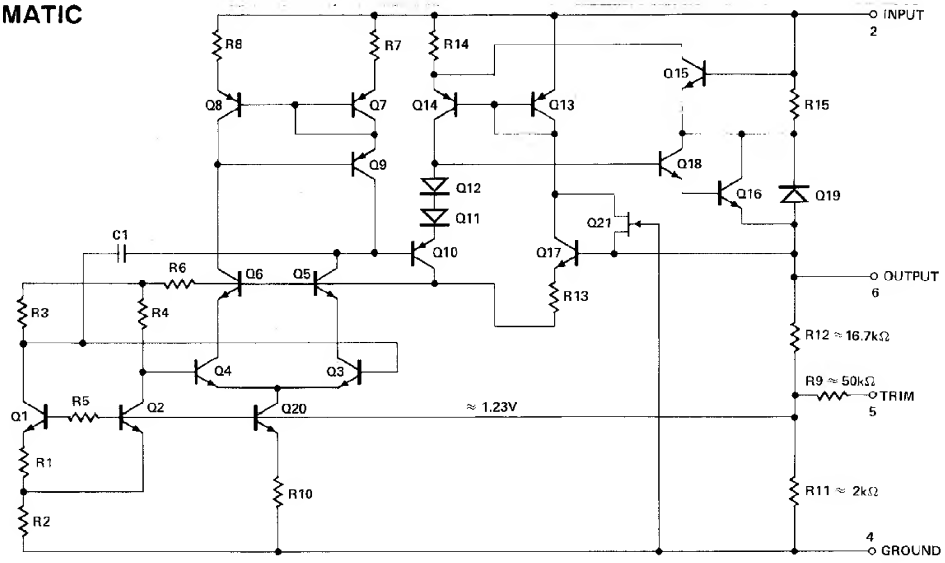
8-PIN HERMETIC DIP
(Z-Suffix)

8-PIN SO
(S-Suffix)



REF-01RC/883
LCC
(RC-Suffix)

SIMPLIFIED SCHEMATIC



REV. B

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 617/329-4700 Fax: 617/326-8703 Twx: 710/394-6577
Telex: 924491 Cable: ANALOG NORWOODMASS

ABSOLUTE MAXIMUM RATINGS (Note 1)

Input Voltage
- REF-01, A, E, H, RC, All DICE 40V
- REF-01C 30V

Output Short-Circuit Duration
- (to Ground or V_{IN}) ..... Indefinite

Storage Temperature Range
- J, RC, and Z Packages ..... –65° C to +150°C
- P Package ..... –65°C to +125°C

Operating Temperature Range
- REF-01A, REF-01, REF-01RC ..... –55°C to +125°C
- REF-01E, REF-01H, REF-01CJ, REF-01CZ ..... 0°C to +70°C
- REF-01CP, REF-01CS ..... –40°C to +85°C

Junction Temperature (T_J) ..... –65°C to +150°C
Lead Temperature (Soldering, 60 sec) ..... 300°C

PACKAGE TYPE	Θ_{JA} (NOTE 2)	Θ_{JC}	UNITS
TO-99 (J)	170	24	°C/W
8-Pin Hermetic DIP (Z)	162	26	°C/W
8-Pin Plastic DIP (P)	110	50	°C/W
20-Contact LCC (RC)	120	40	°C/W
8-Pin SO (S)	160	44	°C/W
20-Contact PLCC (PC)	80	39	°C/W

NOTES:
1. Absolute maximum ratings apply to both DICE and packaged parts, unless otherwise noted.
2. Θ_{JA} is specified for worst case mounting conditions, i.e., Θ_{JA} is specified for device in socket for TO, CerDIP, P-DIP, and LCC packages; Θ_{JA} is specified for device soldered to printed circuit board for SO and PLCC packages.

ELECTRICAL CHARACTERISTICS at V_{IN} = +15V, T_A = 25°C, unless otherwise noted.

			REF-01A/E			REF-01/H			
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
Output Voltage	V_O	I_L = 0	9.97	10.00	10.03	9.95	10.00	10.05	V
Output Adjustment Range	ΔV_{trim}	R_p = 10kΩ	±3.0	±3.3	—	±3.0	±3.3	—	%
Output Voltage Noise	e_{np-p}	0.1Hz to 10Hz (Note 6)	—	20	30	—	20	30	μV_{p-p}
Line Regulation (Note 4)		V_{IN} = 13V to 33V	—	0.006	0.010	—	0.006	0.010	%/V
Load Regulation (Note 4)		I_L = 0 to 10mA	—	0.005	0.008	—	0.006	0.010	%/mA
Turn-on Settling Time	t_{on}	To ±0.1% of final value	—	5	—	—	5	—	μs
Quiescent Supply Current	I_{SY}	No Load	—	1.0	1.4	—	1.0	1.4	mA
Load Current	I_L		10	21	—	10	21	—	mA
Sink Current	I_S	(Note 7)	–0.3	–0.5	—	–0.3	–0.5	—	mA
Short-Circuit Current	I_{SC}	V_O = 0	—	30	—	—	30	—	mA

ELECTRICAL CHARACTERISTICS at V_{IN} = +15V, –55°C ≤ T_A ≤ +125°C for REF-01 A/E, and 0°C ≤ T_A ≤ +70°C for REF-01 H and I_L = 0mA, unless otherwise noted.

			REF-01A/E			REF-01/H			
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNITS
Ouput Voltage Change with Temperature (Notes 1, 2)	ΔV_{OT}	0°C ≤ T_A ≤ +70°C	—	0.02	0.06	—	0.07	0.17	%
		–55°C ≤ T_A ≤ +125°C	—	0.06	0.15	—	0.18	0.45	
Output Voltage Temperature Coefficient	TCV_O	(Note 3)	—	3.0	8.5	—	10.0	25.0	ppm/°C
Change in V_O Temperature Coefficient with Output Adjustment		R_p = 10kΩ	—	0.7	—	—	0.7	—	ppm/%
Line Regulation (V_{IN} = 13V to 33V) (Note 4)		0°C ≤ T_A ≤ +70°C	—	0.007	0.012	—	0.007	0.012	%/V
		–55°C ≤ T_A ≤ +125°C	—	0.009	0.015	—	0.009	0.015	
Load Regulation (I_L = 0 to 8mA) (Note 4)		0°C ≤ T_A ≤ +70°C	—	0.006	0.010	—	0.007	0.012	%/mA
		–55°C ≤ T_A ≤ +125°C	—	0.007	0.012	—	0.009	0.015	

NOTES:
1. ΔV_{OT} is defined as the absolute difference between the maximum output voltage and the minimum output voltage over the specified temperature range expressed as a percentage of 10V:

$$\Delta V_{OT} = \left| \frac{V_{MAX} - V_{MIN}}{10V} \right| \times 100$$

2. ΔV_{OT} specification applies trimmed to +10.000V or untrimmed.
3. TCV_O is defined as ΔV_{OT} divided by the temperature range, i.e.,

$$TCV_O\ (0° \text{ to } +70°C) = \frac{\Delta V_{OT}\ (0° \text{ to } +70°C)}{70°C}$$

$$\text{and } TCV_O\ (-55° \text{ to } +125°C) = \frac{\Delta V_{OT}\ (-55° \text{ to } +125°C)}{180°C}$$

4. Line and Load Regulation specifications include the effect of self heating.
5. Guaranteed by design.
6. Sample tested.
7. During sink current test the device meets the output voltage specified.

ELECTRICAL CHARACTERISTICS at $V_{IN} = +15V$, $T_A = 25°C$, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	REF-01C MIN	REF-01C TYP	REF-01C MAX	UNITS
Output Voltage	V_O	I_L = 0mA	9.90	10.00	10.10	V
Output Adjustment Range	ΔV_{trim}	R_p = 10kΩ	±2.7	±3.3	—	%
Output Voltage Noise	e_{np-p}	0.1Hz to 10Hz (Note 6)	—	25	35	μV_{p-p}
Line Regulation (Note 4)		V_{IN} = 13V to 30V	—	0.009	0.015	%/V
Load Regulation (Note 4)		I_L = 0 to 8mA	—	0.006	0.015	%/mA
Turn-on Settling Time	t_{ON}	To ±0.1% of final value	—	5	—	μs
Quiescent Supply Current	I_{SY}	No Load	—	1.0	1.6	mA
Load Current	I_L		8	21	—	mA
Sink Current	I_S	(Note 7)	−0.3	−0.5	—	mA
Short-Circuit Current	I_{SC}	V_O = 0	—	30	—	mA

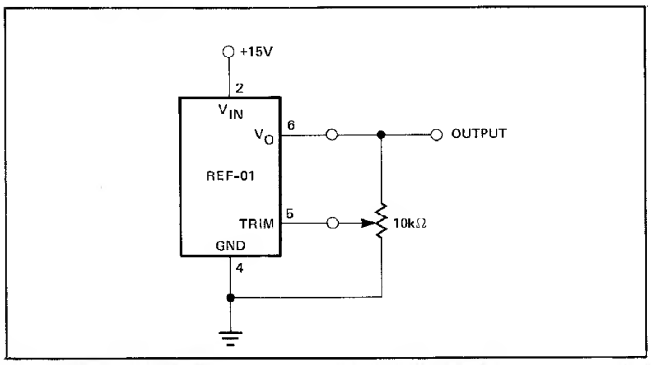
ELECTRICAL CHARACTERISTICS at V_{IN} = +15V°C ≤ T_A ≤ +70°C for REF-01CJ, CZ, −40°C ≤ T_A ≤ +85°C for REF-01CP,CS, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	REF-01C MIN	REF-01C TYP	REF-01C MAX	UNITS
Ouput Voltage Change with Temperature	ΔV_{OT}	(Notes 1 and 2)	—	0.14	0.45	%
Output Voltage Temperature Coefficient	TCV_O	(Note 3)	—	20	65	ppm/°C
Change in V_O Temperature Coefficient with Output Adjustment		R_p = 10kΩ	—	0.7	—	ppm/%
Line Regulation (Note 4)		V_{IN} = 13V to 30V	—	0.011	0.018	%/V
Load Regulation (Note 4)		I_L = 0 to 5mA	—	0.008	0.018	%/mA

NOTES:

1. ΔV_{OT} is defined as the absolute difference between the maximum output voltage and the minimum output voltage over the specified temperature range expressed as a percentage of 10V:
$$\Delta V_{OT} = \left| \frac{V_{MAX} - V_{MIN}}{10V} \right| \times 100$$
2. ΔV_{OT} specification applies trimmed to +10.000V or untrimmed.
3. TCV_O is defined as ΔV_{OT} divided by the temperature range, i.e.,
$$TCV_O = \frac{\Delta V_{OT}}{70°C}$$
4. Line and Load Regulation specifications include the effect of self heating.
5. Guaranteed by design.
6. Sample tested.
7. During sink current test the device meets the output voltage specified.

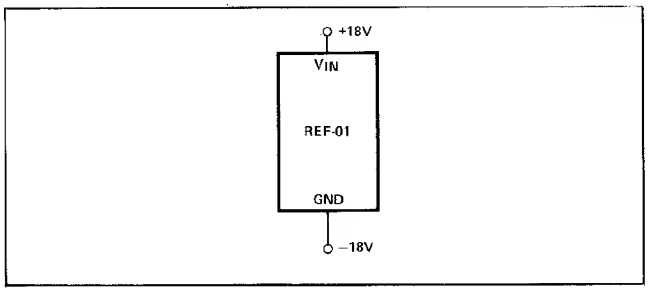
OUTPUT ADJUSTMENT



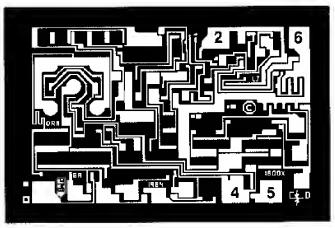
The REF-01 trim terminal can be used to adjust the output voltage over a 10V ±300mV range. This feature allows the system designer to trim system errors by setting the reference to a voltage other than 10V. Of course, the output can also be set to exactly 10.000V, or to 10.240V for binary applications.

Adjustment of the output does not significantly affect the temperature performance of the device. The temperature coefficient change is approximately 0.7 ppm/°C for 100mV of output adjustment.

BURN-IN CIRCUIT



DICE CHARACTERISTICS (125° C TESTED DICE AVAILABLE)



DIE SIZE 0.074 × 0.048 inch, 3552 sq. mils
(1.88 × 1.22 mm, 2.29 sq. mm)

2. INPUT VOLTAGE (V_{IN})
4. GROUND
5. TRIM
6. OUTPUT VOLTAGE (V_{OUT})

WAFER TEST LIMITS at $V_{IN} = +15V$, $T_A = 25°C$ for REF-01N and REF-01G devices; $T_A = 125°C$ for REF-01NT and REF-01GT devices, unless otherwise noted. (Note 1)

PARAMETER	SYMBOL	CONDITIONS	REF-01NT LIMIT	REF-01N LIMIT	REF-01GT LIMIT	REF-01G LIMIT	UNITS
Output Voltage	V_O	$I_L = 0$	10.05 9.95	10.03 9.97	10.10 9.90	10.05 9.95	V MAX V MIN
Output Adjustment Range	V_{trim}	$R_P = 10k\Omega$	—	±3.0	—	±3.0	% MIN
Line Regulation		$V_{IN} = 13V$ to $33V$	0.015	0.01	0.015	0.01	%/V MAX

NOTE:
Electrical tests are performed at wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualification through sample lot assembly and testing.

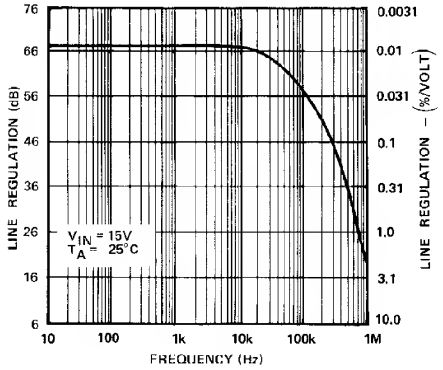
TYPICAL ELECTRICAL CHARACTERISTICS at $V_{IN} = +15V$, $T_A = 25°C$, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	REF-01NT TYPICAL	REF-01N TYPICAL	REF-01GT TYPICAL	REF-01G TYPICAL	UNITS
Load Regulation		$I_L = 0$ to 10mA $I_L = 0$ to 8mA, NT, GT @ +125° C	0.007	0.005	0.009	0.006	%/mA
Output Voltage Noise	e_{np-p}	0.1Hz to 10Hz	20	20	20	20	μV_{p-p}
Turn-On Settling Time	t_{ON}	To ±0.1% of Final Value NT, GT @ +125° C	7.5	5.0	7.5	5.0	μs
Quiescent Current	I_{SY}	No Load, NT, GT @ +125° C	1.4	1.0	1.4	1.0	mA
Load Current	I_L		21	21	21	21	mA
Sink Current	I_S		−0.5	−0.5	−0.5	−0.5	mA
Short-Circuit Current	I_{SC}	$V_O = 0$	30	30	30	30	mA
Output Voltage Temperature Coefficient	TCV_O		10	10	10	10	ppm/° C

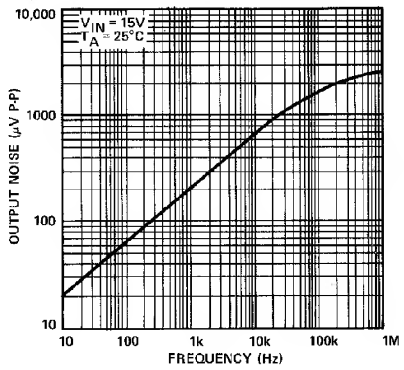
NOTE:
1. For +25° C specifications of REF-01NT and REF-01GT, see REF-01N and REF-01G respectively.

TYPICAL PERFORMANCE CHARACTERISTICS

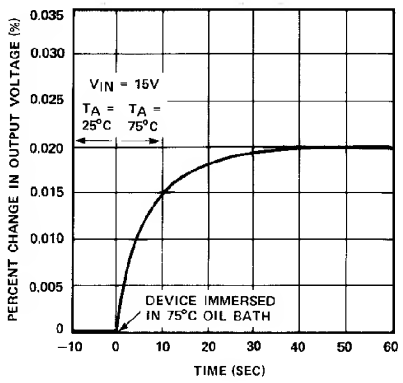
LINE REGULATION vs FREQUENCY



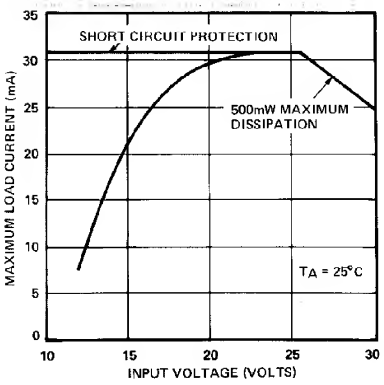
OUTPUT WIDEBAND NOISE vs BANDWIDTH (0.1Hz TO FREQUENCY INDICATED)



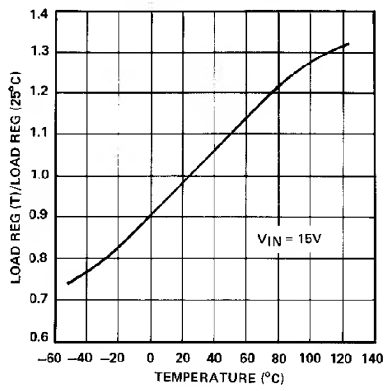
OUTPUT CHANGE DUE TO THERMAL SHOCK



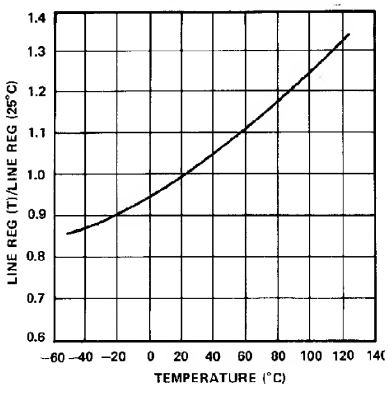
MAXIMUM LOAD CURRENT vs INPUT VOLTAGE



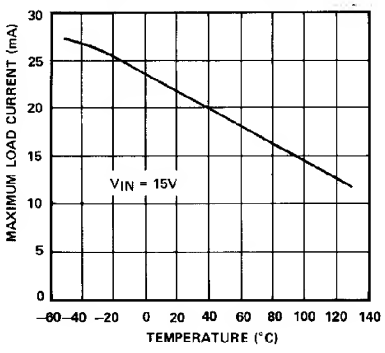
NORMALIZED LOAD REGULATION (ΔI_L = 10mA) vs TEMPERATURE



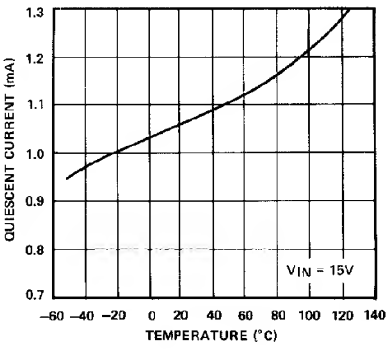
NORMALIZED LINE REGULATION vs TEMPERATURE



MAXIMUM LOAD CURRENT vs TEMPERATURE

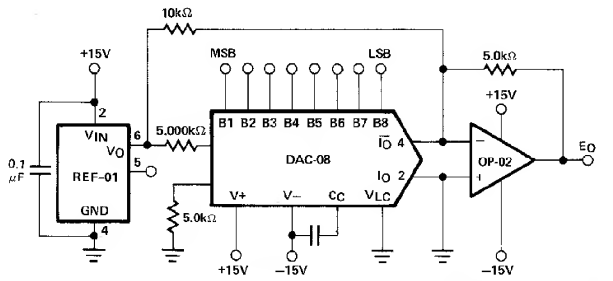


QUIESCENT CURRENT vs TEMPERATURE



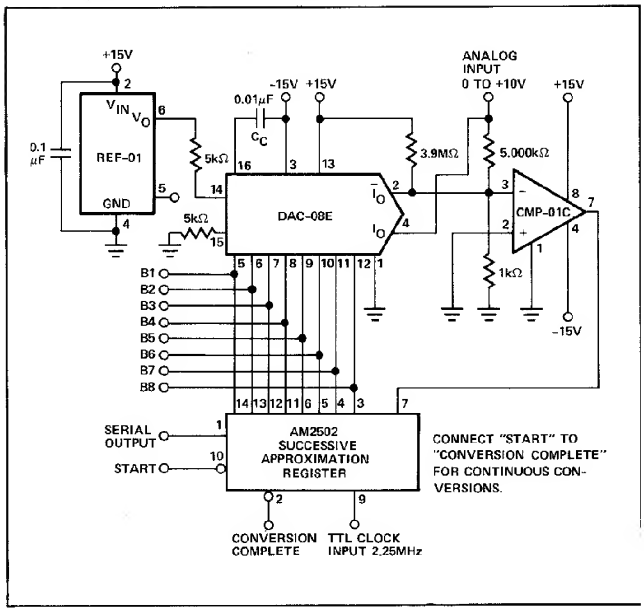
TYPICAL APPLICATIONS

D/A CONVERTER REFERENCE

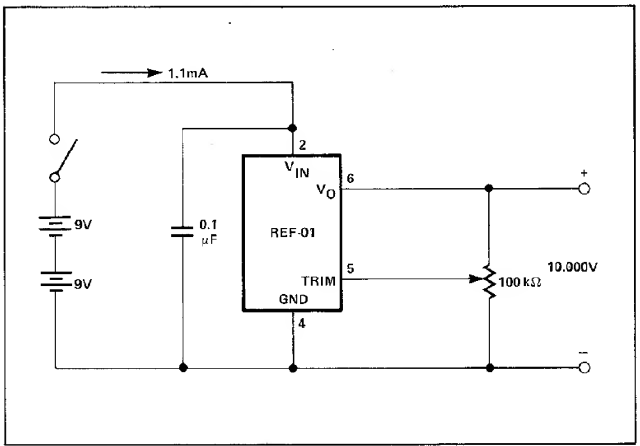


	B1	B2	B3	B4	B5	B6	B7	B8	E
POS. FULL-SCALE −1 LSB	1	1	1	1	1	1	1	1	+4.960
ZERO—SCALE	1	0	0	0	0	0	0	0	0.000
NEG. FULL-SCALE +1 LSB	0	0	0	0	0	0	0	1	−4.960
NEG. FULL-SCALE	0	0	0	0	0	0	0	0	−5.000

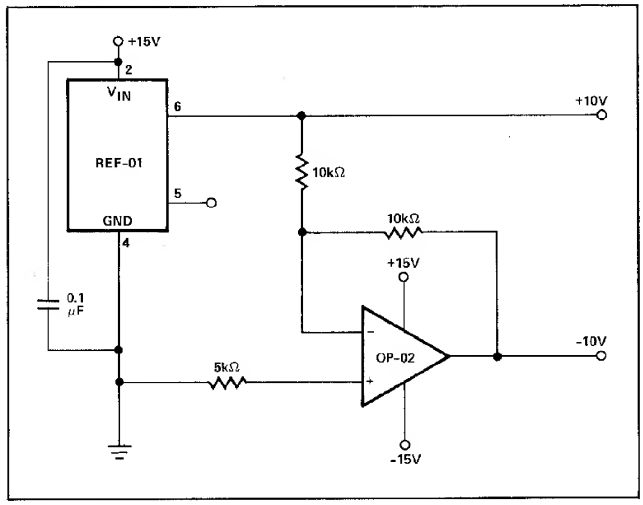
A/D CONVERTER REFERENCE



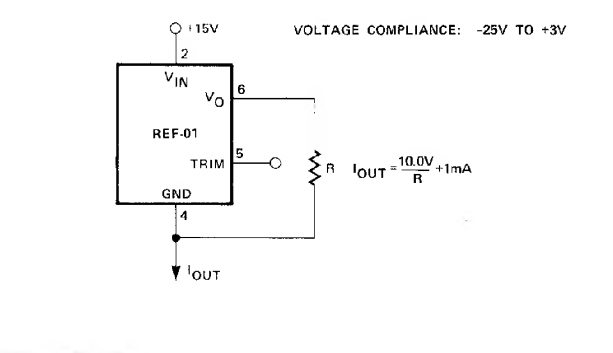
PRECISION CALIBRATION STANDARD



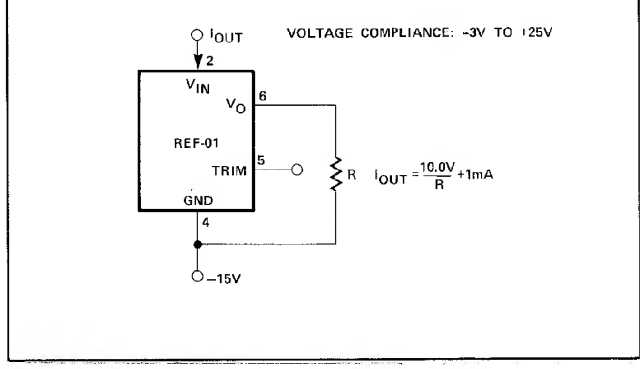
±10V REFERENCE



CURRENT SOURCE



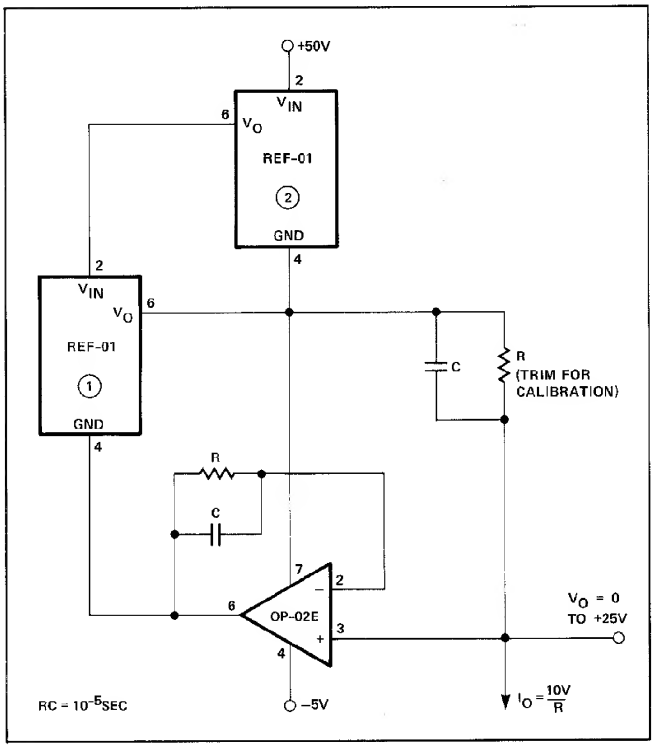
CURRENT SINK



PRECISION CURRENT SOURCE

A current source with 25V output compliance and excellent output impedance can be obtained using this circuit. REF-01 (2) keeps the line voltage and power dissipation constant in device (1); the only important error consideration at room temperature is the negative supply rejection of the op amp. The typical 3μV/V PSRR of the OP-02E will create an 8ppm change (3μV/V × 25V/10V) in output current over a 25V range. For example, a 10mA current source can be built (R = 1kΩ) with 300MΩ output impedance.

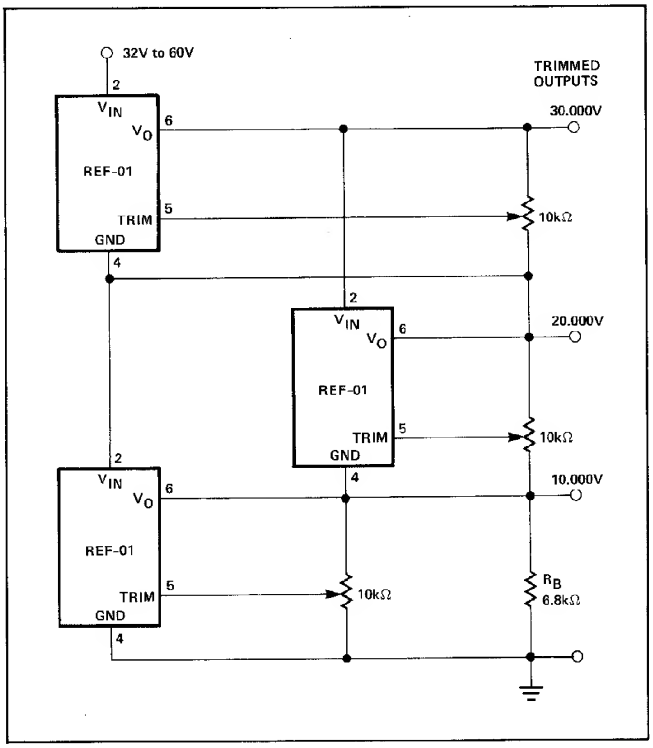
$$R_O = \frac{25V}{8 \times 10^{-6} \times 10mA}$$



REFERENCE STACK WITH EXCELLENT LINE REGULATION

Three REF-01's can be stacked to yield 10.000, 20.000, and 30.000V outputs. An additional advantage is near-perfect line regulation of the 10.0V and 20.0V output. A 32V to 60V input change produces an output change which is less than the noise voltage of the devices. A load bypass resistor (R_B) provides a path for the supply current (I_{SY}) of the 20.000V regulator.

In general, any number of REF-01's can be stacked this way. For example, ten devices will yield outputs of 10, 20, 30 . . . 100V. The line voltage can range from 105V to 130V. However, care must be taken to ensure that the total load currents do not exceed the maximum usable current (typically 21mA).



SUPPLY BYPASSING

For best results, it is recommended that the power supply pin is bypassed with a 0.1μF disc ceramic capacitor.